Analysis of Scintillator051.lst
F. J. Wysocki
September 17, 2008

Data taken by: Hubert Van Hecke, Haruo Miyadera, Jeff Wang, September 5, 2008
Channel #3 had signal from a ^{3}He tube
Channel #2 had signal from a scintillator
A californium source was present
Counting duration was 600 seconds

The pulse height spectra are shown in Figures 1 and 2.

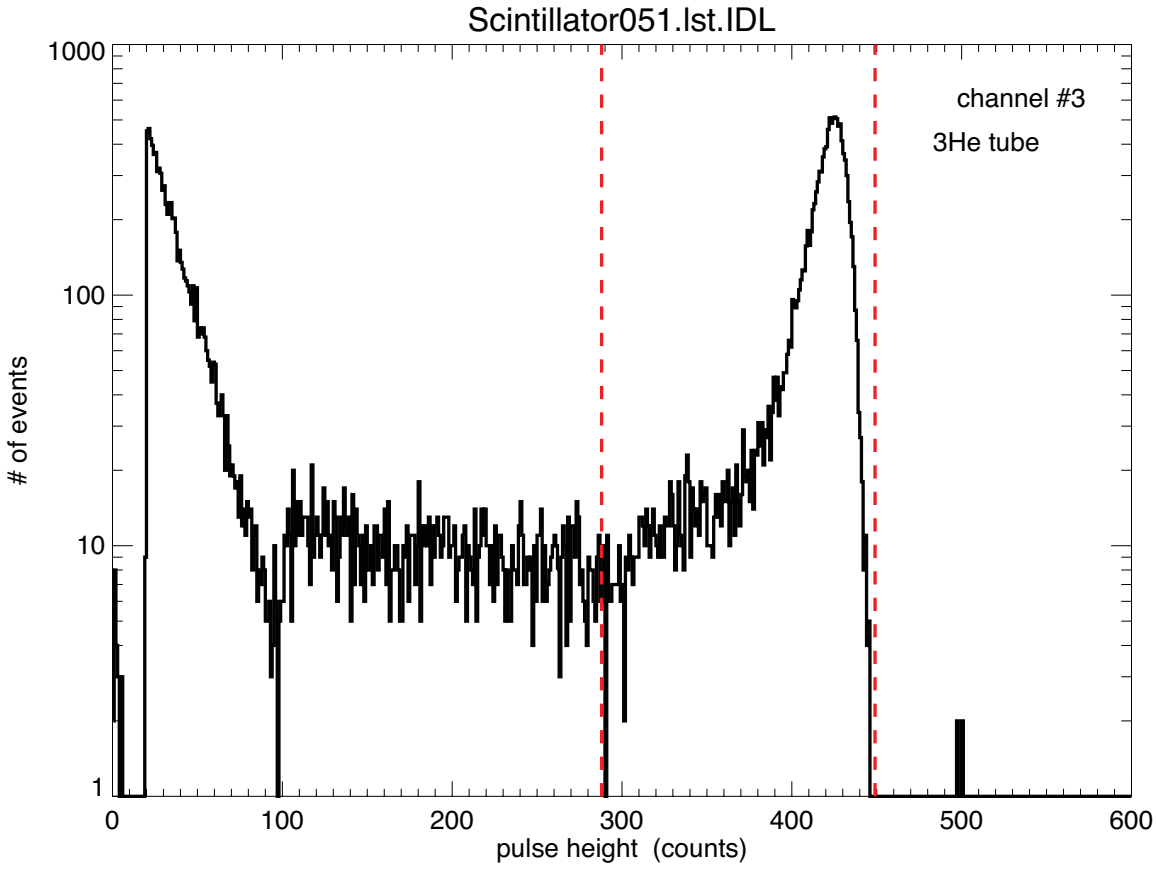

Figure 1: Pulse height spectrum from the ^{3}He tube. There are 22,554 total counts in the spectrum. The analysis includes only counts with pulse height that are between the two red lines, which is 12,573 counts. These counts are expected to be neutron events.

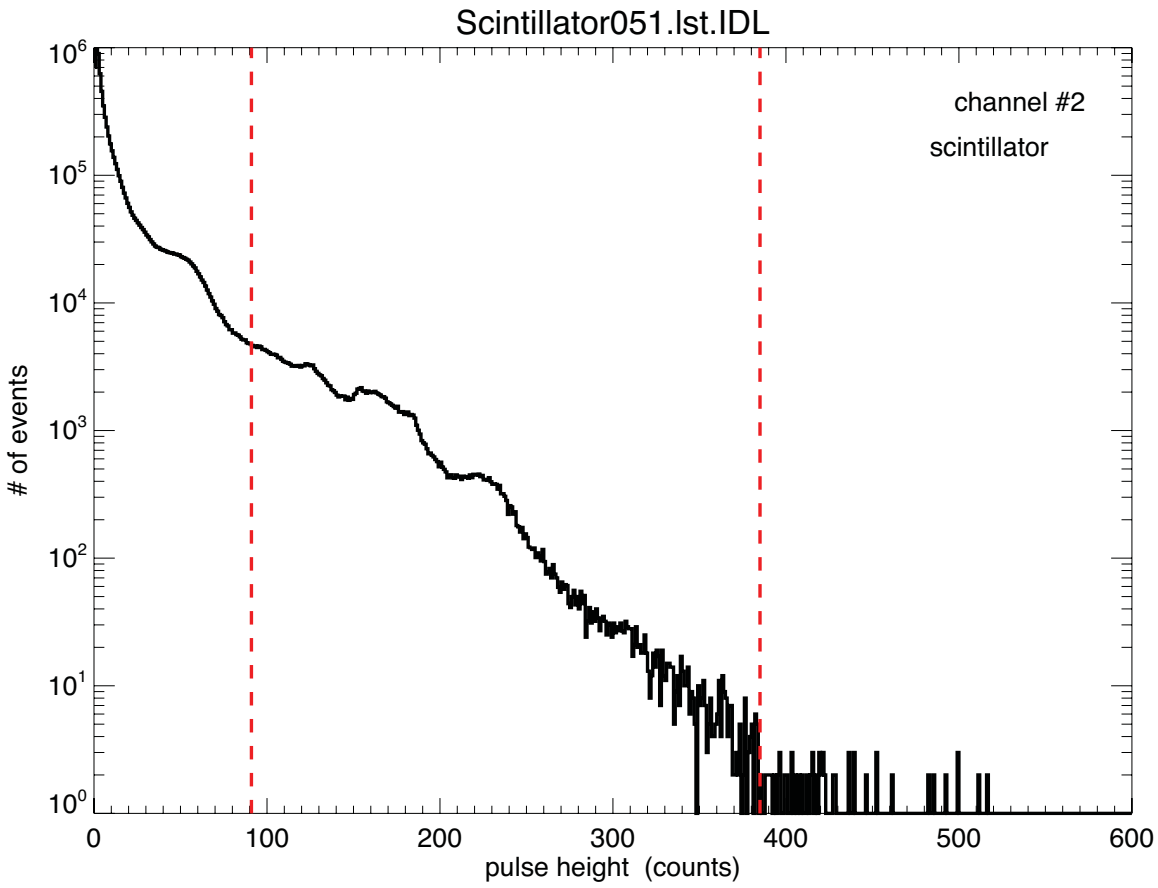

Figure 2: Pulse height spectrum from the scintillator. There are 7,960,273 total counts in the spectrum. The analysis includes only counts with pulse height that are between the two red lines, which is 280,061 counts.

The data were collected in "list" mode, which includes a time-stamp for every count. The time stamp is recorded with 50 ns resolution. (I don't know the accuracy of the time stamp.) A time coincidence analysis was performed where for each ^{3}He count, the nearest scintillator count just prior in time, and just after in time were identified, and the time difference with respect to the ^{3}He count for both were saved. The goal is to identify likely correlated neutron events that produced a count in the scintillator and then produced a count in the ^{3}He tube within approximately 200 μs. The "after" events in the scintillator should be unrelated to the reference ^{3}He count, and represent a "background" in the time coincidence space. The "prior" events are also likely unrelated if the time difference is beyond ~ 200 μs. A histogram of those time differences is shown in Figure 3 over a wide time range. Negative time is the "prior" scintillator event while positive time is the "after" event. The width of the wings of ~ 2 ms is directly determined by the effective count rate in the scintillator data stream; i.e., 280,061 counts in 600 seconds is a rate of 467 s^{-1}, and the inverse is 2.1 ms.

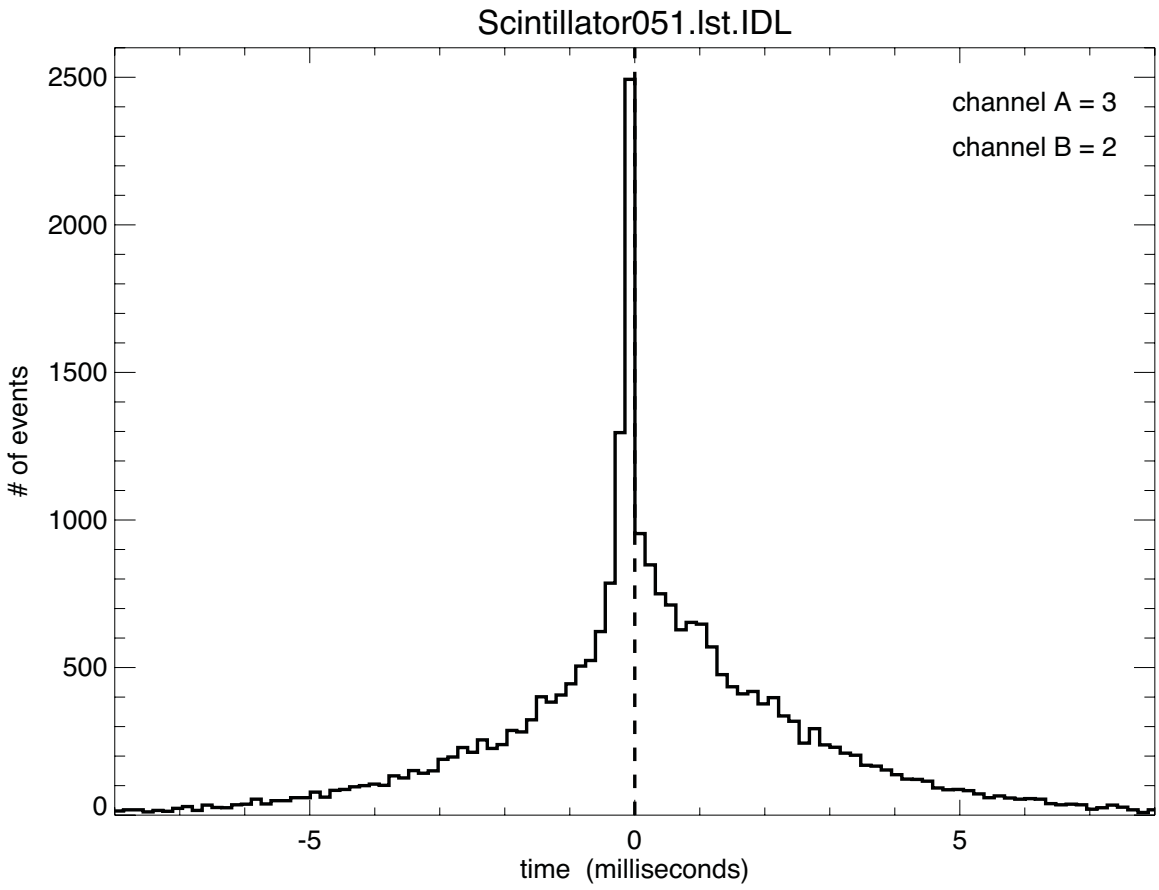

Figure 3: Histogram of the time difference between the two nearest scintillator counts (just before and just after) to each ^{3}He count.

Figure 4 shows the same analysis for a smaller time window. The asymmetric feature about the zero time in the histogram represents the events we are trying to identify, i.e., neutrons that first create a count in the scintillator and then a count in the ^{3}He tube. Figure 5 shows the result of flipping the time-positive portion of the histogram about zero and subtracting this from the time-negative portion. The width of the remaining feature is ~ 200 μs, as expected.

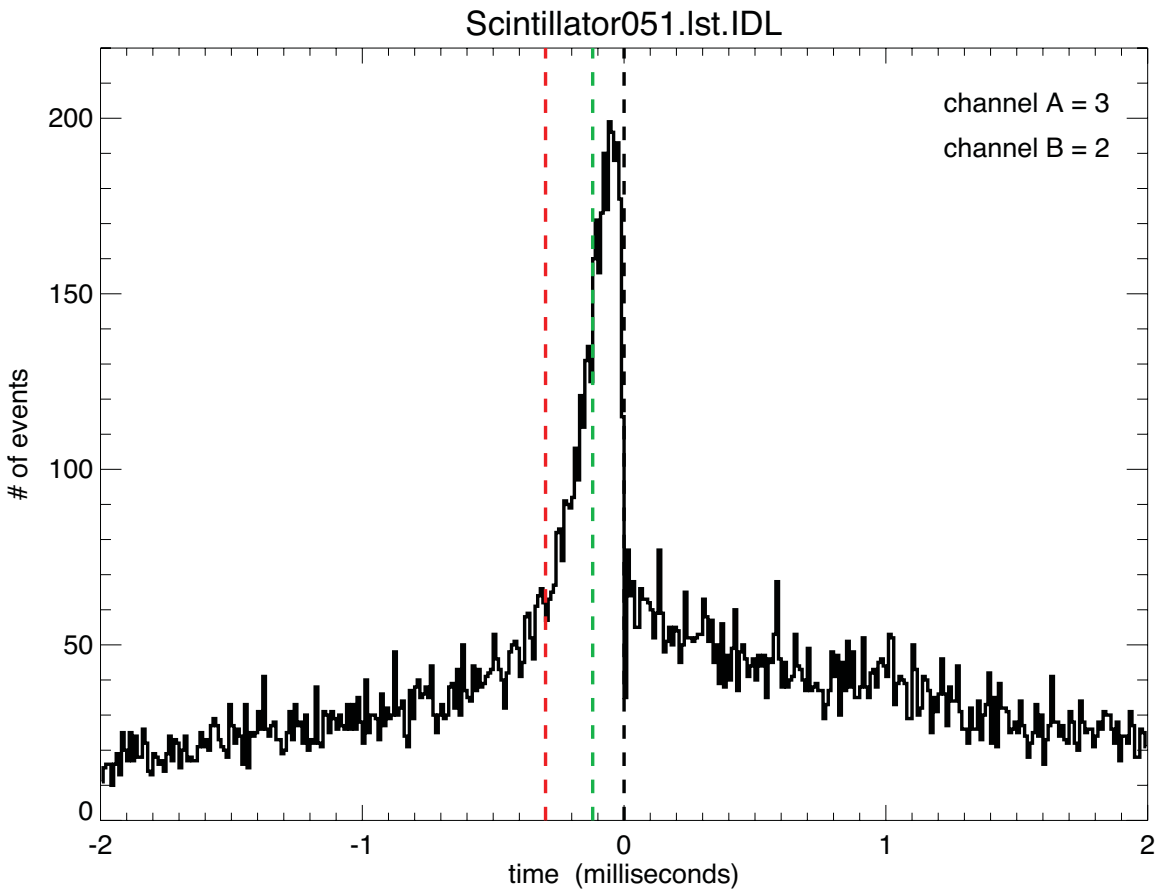

Figure 4: Histogram of the same data set of Figure 3, but in a smaller time window. The red and green lines are used to define a time threshold in subsequent analysis shown in Figures 6 and 7.

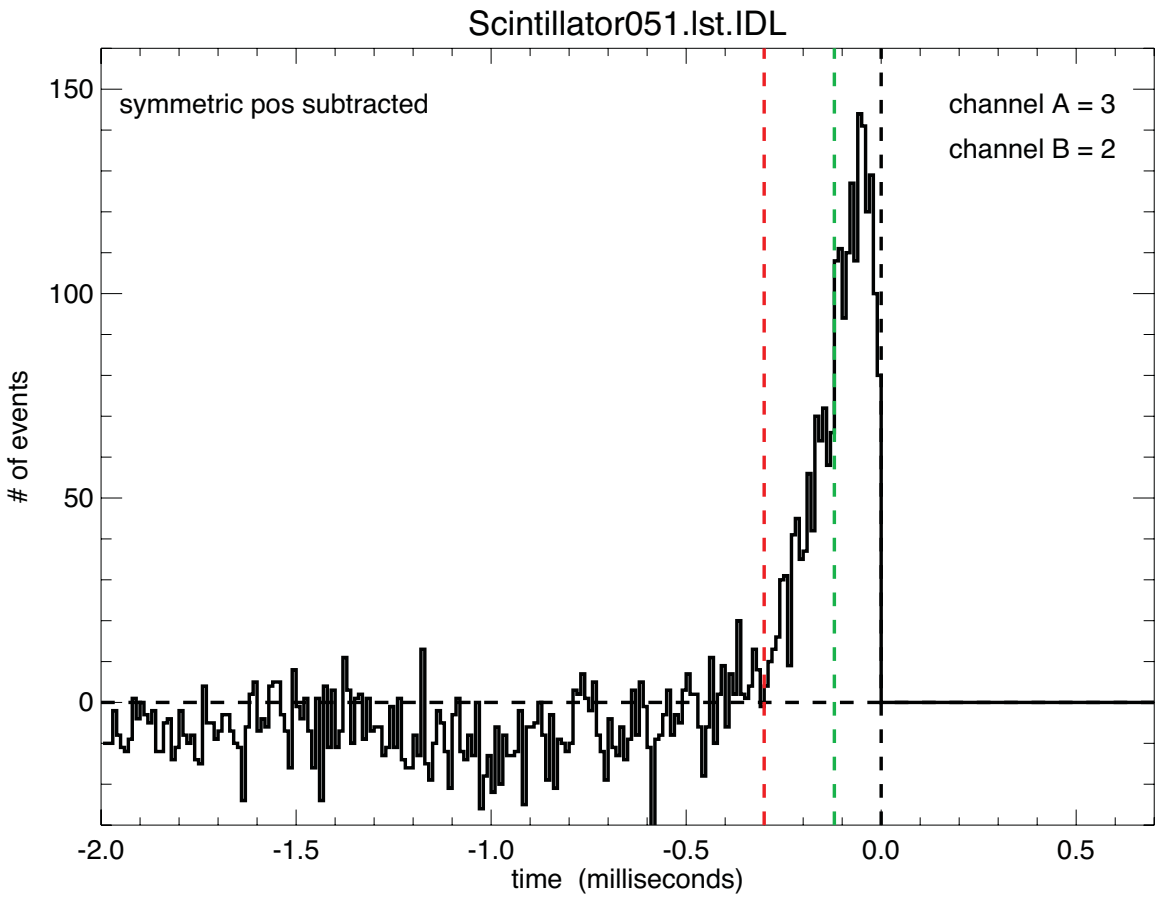

Figure 5: Result of time symmetrizing the positive-time portion of Figure 4 and subtracting that result from the curve in Figure 4. The red and green lines are used to define a time threshold in subsequent analysis shown in Figures 6 and 7, and are at the same position as in Figure 4.

The next step is a determination of the pulse-height spectrum for counts in the scintillator that precede a ^{3}He count by up to a maximum time. Two values of this maximum time are considered below, as indicated by the red and green lines in Figures 4 and 5. Only events between the red (or green) line and zero time are considered for the new pulse-height spectrum. The results for the larger time window (red line in Figures 4 and 5) are shown in Figure 6, and the smaller time window (green line in Figures 4 and 5) in Figure 7.

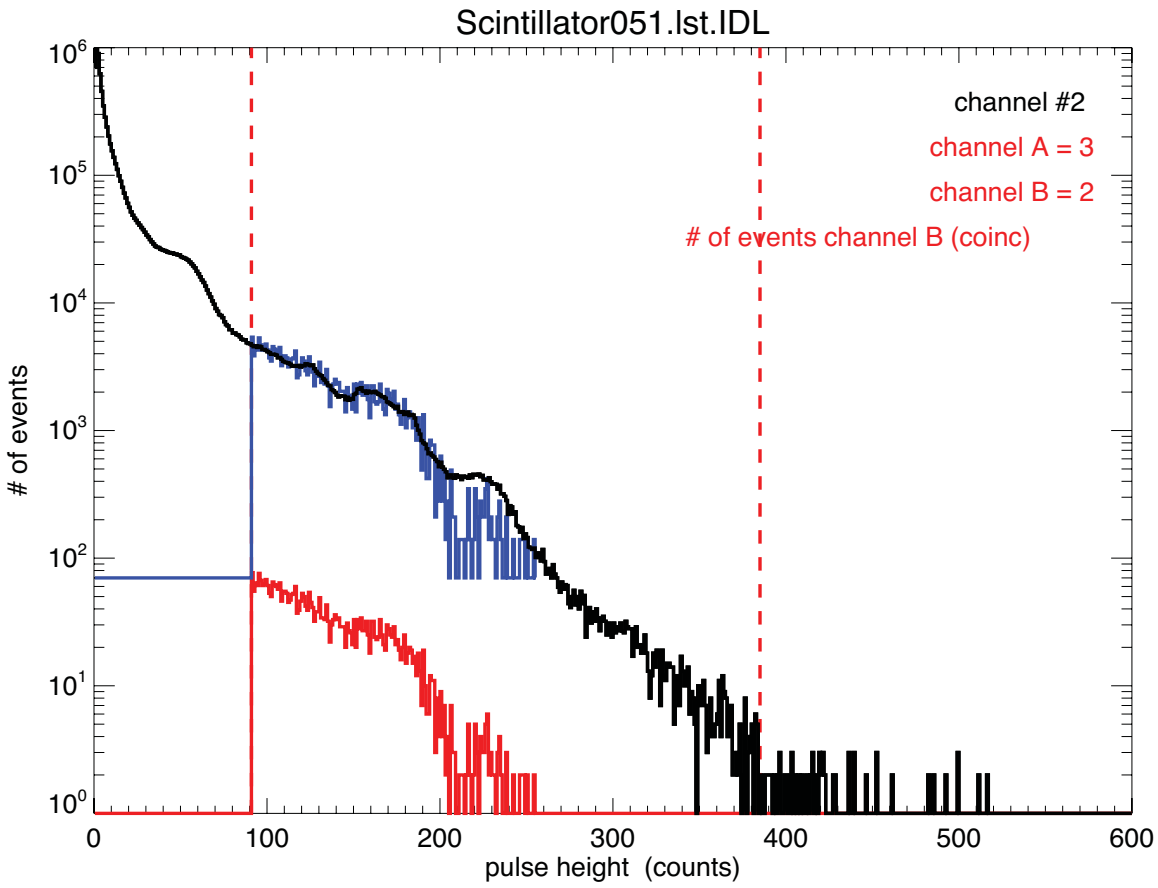

Figure 6: The black curve is the original spectrum shown in Figure 2. The red curve corresponds to the time-window indicated by the red line in Figures 4 and 5 (window is between zero time and time indicated by the red line). The blue curve is the red curve multiplied by 70 so that the shape can be more easily compared to the original curve.

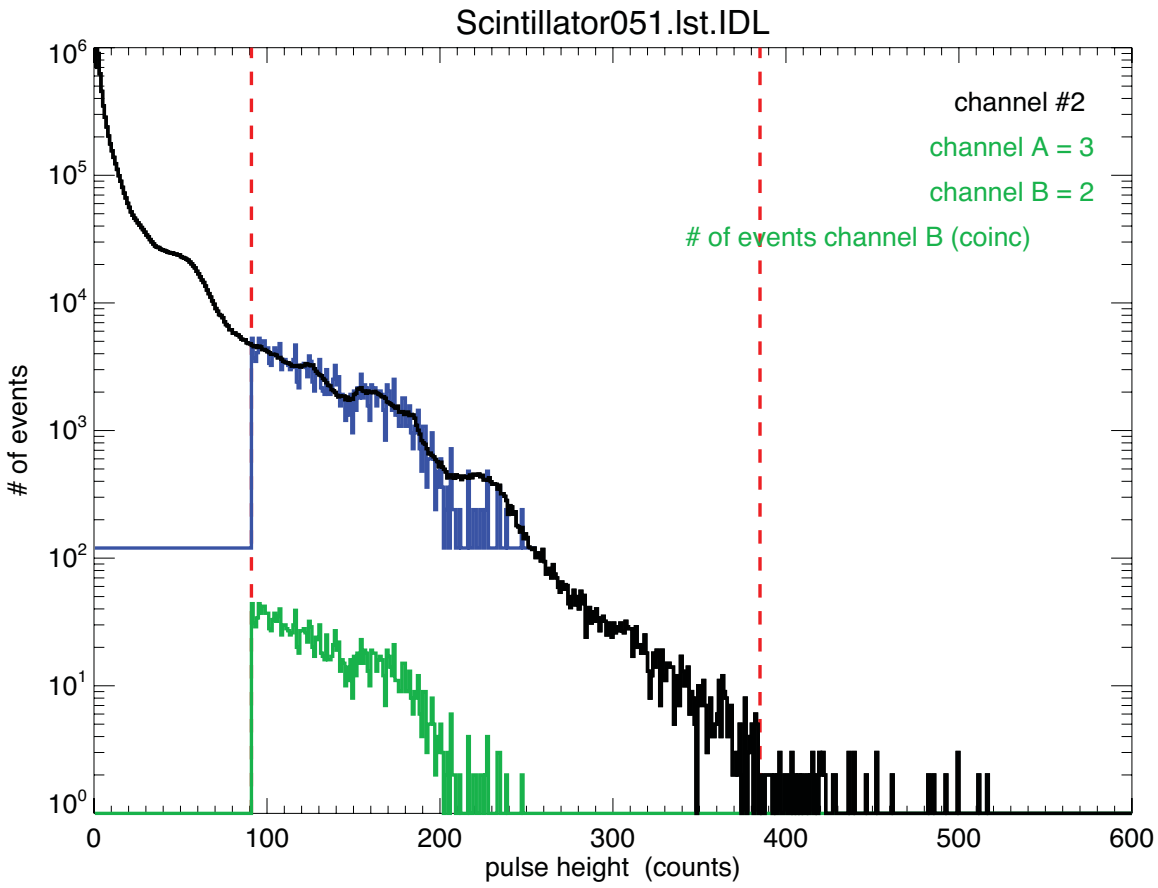

Figure 7: The black curve is the original spectrum shown in Figure 2. The green curve corresponds to the time-window indicated by the green line in Figures 4 and 5 (window is between zero time and time indicated by the green line). The blue curve is the green curve multiplied by 120 so that the shape can be more easily compared to the original curve.

The shape of the new spectrum is essentially unchanged from the minimum pulse-height considered (91 in these units) to ~ 195. The hump at ~ 215 is depressed, perhaps even eliminated in Figure 7. The count rate in the new spectrum is too low above pulse-heights of ~ 240 to draw conclusions about changes to the spectrum shape for higher pulse heights.

The results from lowering the minimum pulse-height considered in the original scintillator spectrum from 91 to 39 are summarized in Figures 8 and 9. This includes 1,025,491 counts of the original scintillator spectrum. Now the wings of the time histogram are not symmetric, and the subtraction of the symmetrized positive portion does not cancel the negative wing nearly as well as in Figure 5, leaving the negative going region of the curve. I do not presently understand what causes this.

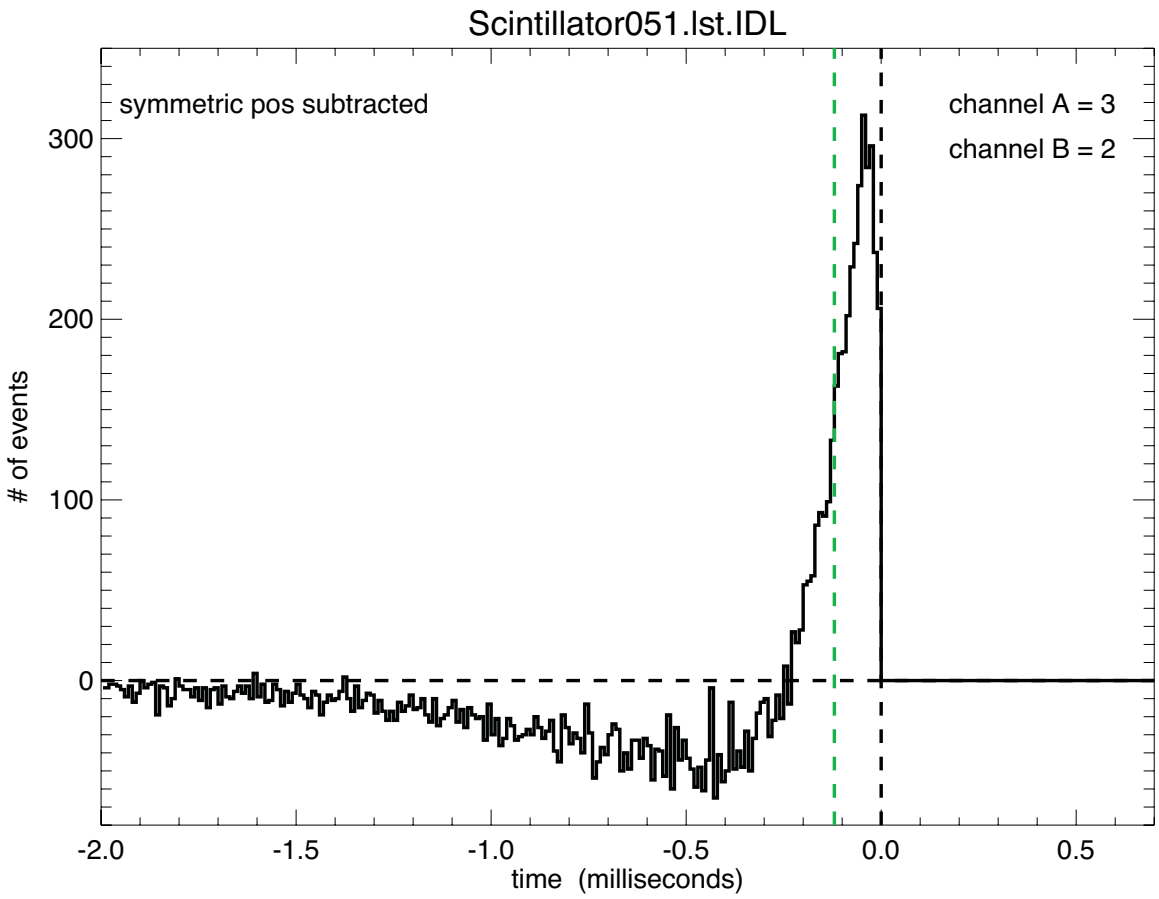

Figure 8: Equivalent result as Figure 5, except the minimum pulse-height of Figure 2 has been lowered from 91 to 39. The green line is used to define a time threshold for the results shown in Figure 9.

The new spectrum constructed from considering only counts between the green line of Figure 8 and zero time is shown in Figure 9. Compared to Figure 7, the main new piece of information is the reduction of the shoulder at pulse-height of ~ 53 (in these units). This suggests that most of the counts below this pulse-height are not neutrons.

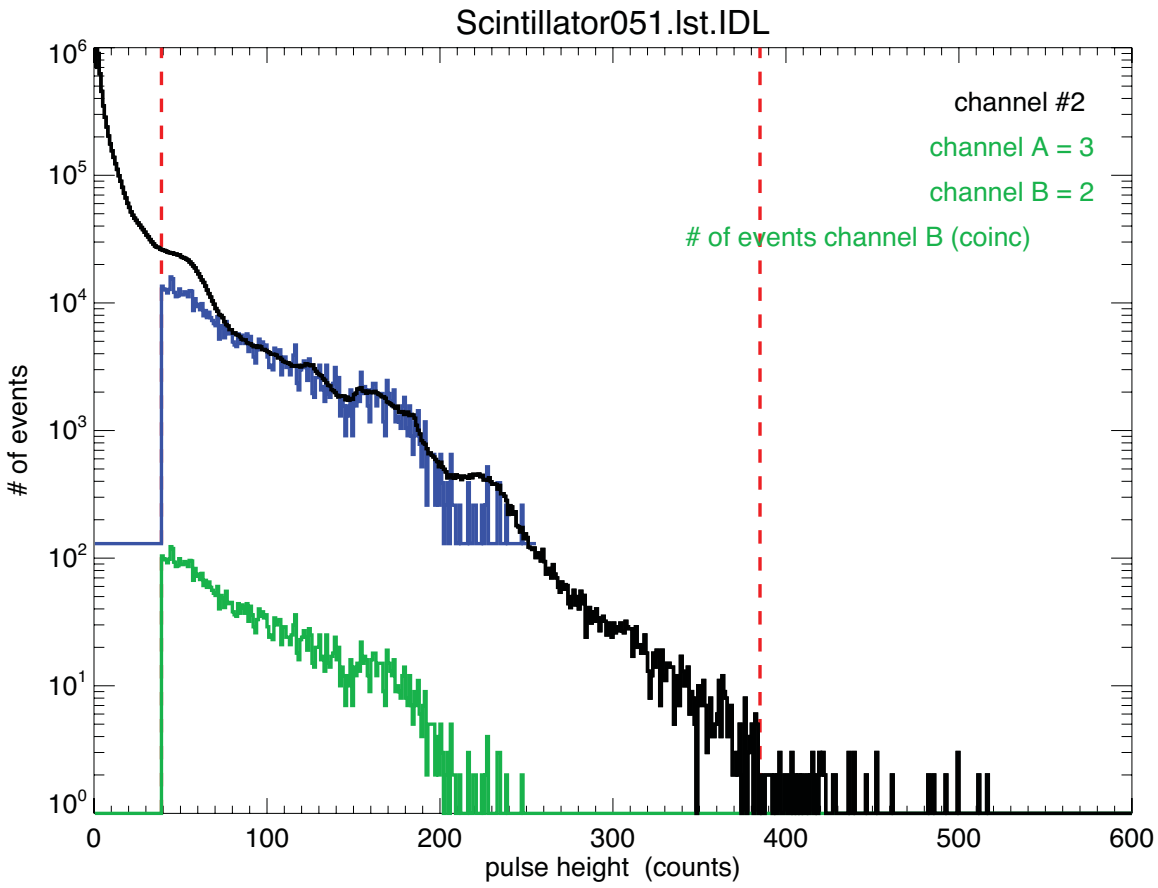

Figure 9: Equivalent result as Figure 7, except the minimum pulse-height of Figure 2 has been lowered from 91 to 39. The black curve is the original spectrum shown in Figure 2. The green curve corresponds to the time-window indicated by the green line in Figure 8. The blue curve is the green curve multiplied by 130 so that the shape can be more easily compared to the original curve.

The following table describes how many scintillator counts occur within the specified time window prior to a ^{3}He count. This is tabulated for zero scintillator counts, one count, or more than one count.

PH lower limit (Fig. 2)	time threshold (Fig. 5)	# of counts	occurance	% occurance
91	120 μs	0	9962	82.0%
91	120 μs	1	2084	17.1%
91	120 μs	> 1	108	0.9%
91	300 μs	0	8345	68.3%
91	300 μs	1	3420	28.0%
91	300 μs	> 1	452	3.7%
39	120 μs	0	7014	56.2%
39	120 μs	1	4554	36.5%
39	120 μs	> 1	911	7.3%
39	300 μs	0	3679	29.4%
39	300 μs	1	5631	45.0%
39	300 μs	> 1	3209	25.6%